3.2 The Effect of Mature Shelterbelts on Microclimate and Crop Yield

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A study was conducted at Conquest Saskatchewan to assess the effects of mature shelterbelts on soil moisture, crop yield, potential evaporation, and windspeed. Three sites were selected on soils from three different soil associations; Asquith, Bradwell and Elstow. Transects perpendicular to the shelterbelts were established and spring soil moisture samples were taken. Seventy-eight kilograms of N per hectare in the form of ammonium nitrate was broadcast on strips parallel to the main transects to control for variations in available N at the sites. Paired yield samples (3 m^2) of both the fertilized and unfertilized transects were taken in the fall. Potential evaporation and windspeed were monitored as a function of distance from the shelterbelts in addition to the measurements of soil moisture and crop yield at the Sibbald site. Table 3.2.1 summarizes the main factors relevant to each of the three locations which include the Clint Sibbald, the Lloyd Tyler, and the Roger Deardall sites.

<u>Sibbald Sites</u>

Spring moisture content (0-60 cm), in the immediate vicinity of the shelterbelts, was as much as 25% above the weighted mean spring moisture contents, which is likely a reflection of snow trapped by the shelterbelts (Table 3.2.2). Soil moisture contents at greater distances from the belts reflect the influence of topography on soil moisture redistribution. Potential evaporation at 6 m from the east shelterbelt was decreased by as much as 23% below values measured at an adjacent open fallow site and approached open site values towards the center of the field. Winds were predominantly from the north-west during the measurement period and wind velocities were reduced by approximately 36% at

Table 3.2.1 Summary of key variables related to each of the Conquest sampling sites.

Variable	Sibbald(a)	Sibbald(b)	Tyler	Deardall
Location	N$^1/_2$,21,30,9	N$^1/_2$,21,30,9	S$^1/_2$,17,30,9	SE$^1/_4$,2,30,9
Soil Type	Bradwell	Bradwell	Asquith	Elstow
Crop Type	Durum	Spring Wheat	Spring Wheat	Spring Wheat
Shelterbelt Information				
Type	Caragana	Caragana	Caragana	Caragana + Elm
Orientation	N-S	N-S	N-S	N-S
Height	6 m	6 m	6 m	12 m
Spacing	181 m	198 m	148 m	250 m
Sampling Information				
Spring Soil Moisture	May 9	May 10	June 3	June 8
Seeding Date	May 17	June 1	May 25	May 8
Fertilized	May 29	June 2	May 29	May 29
Harvest	Aug 13	Aug 15	Aug 12	Aug 9,10
Data Summary				
*Spring Soil Moisture	10.9 cm	9.9 cm	12.4 cm	12.2 cm
Average Yield	1523 kg/ha	1397 kg/ha	1793 kg/ha	1937 kg/ha
Average Biomass	3570 kg/ha	2873 kg/ha	3807 kg/ha	3990 kg/ha
Rainfall (May-Jul)	112 mm	112 mm	150 mm	131 mm

* Soil moisture values represent the weighted average soil moisture content (0-60 cm) for the sampled transect.

6 m from the west shelterbelt compared to windspeeds at 120 m (Kowalchuk and de Jong, 1990). Average yields were relatively low at both the durum and spring wheat sites; 1500 kg/ha and 1400 kg/ha, respectively (Table 3.2.1). A paired t-test of the fertilized and non-fertilized treatments showed that there was no significant difference due to fertilization (å = 5%) which suggests that moisture was limiting crop growth or that the farmer had adequately fertilized the two sites. Yields are known to be a function of the ratio between actual and potential evaporation. Based on the atmometer data we would expect yield near the shelterbelts to be significantly higher than yields at the center of the fields. However, the yield and biomass response as a function of distance from the shelterbelts was relatively

Table 3.2.2 Spring soil moisture (cm to 60 cm depth); Sibbald durum and spring wheat sites and Tyler and Deardall sites.

Sibbald (durum)		Sibbald (wheat)		Tyler		Deardall	
Distance to West SB (m)	Total H_2O (0-60 cm)	Distance to West SB (m)	Total H_2O (0-60 cm)	Distance to West SB (m)	Total H_2O (0-60 cm)	Distance to West SB (m)	Total H_2O (0-60 cm)
0	13	3	13	0	9	0	12
18	10	6	12	3	8	3	15
42	10	9	12	6	12	6	13
78	10	12	12	9	10	9	13
114	13	18	11	15	11	12	14
138	11	30	11	21	11	15	13
150	11	42	8	33	12	27	12
162	11	66	8	45	12	45	15
168	12	132	8	57	13	69	12
171	12	168	10	81	13	105	12
174	10	180	9	105	13	195	12
177	13	183	10	117	14	219	10
180	12	186	10	129	13	231	10
		189	11	135	13	240	12
		195	12	138	12	246	13
				141	12	249	12
				144	10		
				147	9		

flat for both sites (Tables 3.2.3 and 3.2.4). Competition by the belts for available moisture reduced crop yields by as much as 66%. Although the yield reduction zone was confined to a relatively small distance from the shelterbelts, when combined with the lost yield that results from the area occupied by the shelterbelts it represents a significant loss of potential yield on this field. A regression analysis of the spring moisture and yield data indicated that variation in grain yield could not be accounted for by variation in available moisture at seeding time. The lack of a shelterbelt effect with respect to yield regardless of decreases in potential evaporation and windspeed near the belts provides further evidence that moisture stress was the main factor controlling yields within the study area. Precipitation recorded at the site was 30% below the 30 year average for the area. Also, the distribution of the precipitation was skewed so that approximately 80% of the precipitation fell in May while only 20% fell in June and July.

Tyler Site

The low spring moisture content (Table 3.2.2) values near the shelterbelts at this site is a reflection of the late sampling date (Table 3.2.1). Competition by the shelterbelts has reduced soil moisture near the belts by as much as 33% below the average soil moisture for the field. As with the Sibbald sites there was no significant difference in the yields or biomass between the two fertilizer treatments (Table 3.2.5). The yield and biomass values appeared to be much more variable along this transect compared to the Sibbald or the Deardall sites. The higher average yield compared to the Sibbald sites despite the sandy texture of this site is likely a reflection of the higher spring soil moisture and growing season precipitation recorded at this site. No significant yield trend with respect to distance from the shelterbelts was observed at this site.

Table 3.2.3 Sibbald durum site; fertilized and non-fertilized grain weight and total weights as a function of distance from the west shelterbelt.

Distance to West SB (m)	Grain weight 0-N ($g/3\ m^2$)	Total weight 0-N ($g/3\ m^2$)	Grain weight 70-N ($g/3\ m^2$)	Total weight 70-N ($g/3\ m^2$)
5	432	1000	410	938
11	440	1058	406	975
17	440	1042	504	1154
23	382	959	412	907
29	364	782	348	972
35	442	978	385	941
41	393	852	408	1039
47	470	916	438	816
53	444	993	445	959
59	484	1028	372	955
65	409	916	402	1160
71	455	1060	383	1021
77	487	1118	481	1044
83	533	1173	458	1159
89	373	850	454	986
95	369	918	469	837
101	495	1165	408	803
107	393	893	349	881
113	362	858	323	1116
119	515	1147	363	1426
125	720	1622	460	1436
131	638	1411	636	1603
137	602	1603	660	1466
143	638	1405	636	1405
149	672	1545	669	1537
155	520	1096	484	1129
167	462	1073	430	1042
173	370	917	402	983
179	342	384	272	648

Table 3.2.4 Sibbald spring wheat site; fertilized and non-fertilized grain weight and total weights as a function of distance from the west shelterbelt.

Distance to West SB (m)	Grain weight 0-N ($g/3\ m^2$)	Total weight 0-N ($g/3\ m^2$)	Grain weight 70-N ($g/3\ m^2$)	Total weight 70-N ($g/3\ m^2$)
5	168	373	197	393
11	478	973	439	857
17	410	795	511	1011
23	397	754	421	851
29	513	1043	506	981
35	595	1232	561	1101
41	488	992	472	976
47	369	772	398	866
53	379	798	345	732
59	359	797	441	911
65	377	779	392	745
71	431	881	485	959
77	419	878	431	866
98	393	805	391	774
107	429	872	451	967
113	447	917	435	928
119	521	1099	448	926
137	448	927	460	937
143	410	898	438	913
149	404	836	421	883
155	405	810	454	908
161	417	904	422	880
167	444	947	377	809
173	411	876	435	883
179	449	894	454	934
185	447	955	430	893
191	408	822	422	861
197	107	213	317	682

Table 3.2.5 Tyler spring wheat site; fertilized and non-fertilized grain weight and total weights as a function of distance from the west shelterbelt.

Distance to West SB (m)	Grain weight 0-N ($g/3\ m^2$)	Total weight 0-N ($g/3\ m^2$)	Grain weight 70-N ($g/3\ m^2$)	Total weight 70-N ($g/3\ m^2$)
5	571	1161	537	1078
8	746	1546	740	1557
11	740	1553	638	1391
14	758	1521	709	1534
	797	1666	755	1623
20	604	1261	598	1276
23	591	1242	534	1170
26	516	1028	549	1090
29	704	1471	679	1492
32	527	1031	610	1275
35	447	890	743	1522
38	457	947	600	1223
41	223	473	495	1073
44	177	389	590	924
50	303	634	360	715
56	435	913	470	1037
62	437	990	672	1543
68	503	1069	541	1065
74	353	758	279	548
80	325	643	224	502
86	281	591	319	695
92	676	1313	513	1117
98	681	1354	403	1325
104	782	1645	542	1194
110	582	1163	468	1014
113	622	1267	307	709
116	479	995	227	470
119	547	1241	339	730
122	555	1205	416	955
125	691	1625	630	1372
128	683	1531	905	2104
131	740	1634	678	1487
134	433	959	638	1473
140	811	1734	696	1513
143	541	1221	596	1136
146	136	447	288	212

Deardall Site

Soil moisture values at this site did not appear to follow any definite trends as a function of distance from the shelterbelts (Table 3.2.2). As at the Tyler site this field was sampled relatively late in the spring, however there does not appear to be as significant a competition affect near the belts. This farmer, unlike the other two farmers, prunes the sucker roots along the edge of the shelterbelts and is careful to cultivate as close as possible to the edge of the belts in order to control weed growth; these management practices may explain the lack of competition in the early part of the growing season. Competition effects were observed later on in the season as indicated by the depressed yield values near the belts (Table 3.2.6). The yields at this site were about 15% higher than the average yields for all four sites. As at the other fields there was no significant difference in yields or biomass between the fertilized and non-fertilized treatments. The yields at this site appear to be higher near the west shelterbelt, reaching a maximum of about 3000 kg/ha between 25 and 50 m from the west shelterbelt and steadily decreasing to about 1300 kg/ha near the east side of the field. Since winds were predominantly from the north west during the growing season, the higher yield values near the west side of the field may be a reflection of reduced evaporation and windspeed. Moisture stress at this field is less likely than at either of the other sites because the field did receive close the average precipitation (151 mm) for the area.

REFERENCE

Kowalchuk, T.E. and E. de Jong. 1990. The effects of mature shelterbelts on microclimate and yield. Proc. of the 1990 Soils and Crops Workshop, Univ. of Saskatchewan, Saskatoon.

Table 3.2.6 Deardall spring wheat site; fertilized and non-fertilized grain weight and total weights as a function of distance from the west shelterbelt.

Distance to West SB (m)	Grain weight 0-N ($g/3\ m^2$)	Total weight 0-N ($g/3\ m^2$)	Grain weight 70-N ($g/3\ m^2$)	Total weight 70-N ($g/3\ m^2$)
5	256	572	146	300
8	606	1316	499	1099
11	522	1397	505	1088
14	736	1589	564	1181
17	750	1706	638	1558
20	807	1842	900	1868
23	709	1673	851	1810
26	794	1796	709	1414
29	772	1587	705	1473
32	888	1894	825	1812
35	842	1890	778	1593
38	863	1832	810	1641
41	711	1903	905	1929
44	913	1862	735	1722
47	773	1652	750	1652
50	823	1722	868	1607
53	746	1510	620	1264
56	723	1470	719	1626
59	728	1433	519	1003
62	693	1388	728	1442
65	632	1232	642	1296
68	342	1160	556	1133
71	606	1132	628	1179
74	582	1177	706	1190
77	581	986	625	1091
80	506	1107	597	1197
83	552	1133	581	1131
86	452	1057	593	1125
89	485	995	456	901
92	497	973	459	953
95	462	955	618	1216
98	655	979	581	1213
101	529	1054	582	1169
104	452	918	495	995
107	526	1025	546	1006
128	611	1246	620	1220
131	187	1269	610	1287
152	584	1145	660	1319
155	537	1070	695	1403
158	542	1053	537	1061

Table 3.2.6 Continued.

Distance to West SB (m)	Grain weight 0-N ($g/3\ m^2$)	Total weight 0-N ($g/3\ m^2$)	Grain weight 70-N ($g/3\ m^2$)	Total weight 70-N ($g/3\ m^2$)
161	632	1253	526	1098
164	557	1204	511	1179
167	604	1205	609	1206
170	641	1292	552	1063
173	701	1443	668	1336
176	561	1105	474	1065
179	512	1025	558	1085
182	598	1230	589	1134
185	587	1170	478	787
188	416	803	460	882
191	461	908	479	940
194	437	882	496	995
197	548	1077	463	908
200	524	1006	442	939
203	471	905	492	950
206	474	891	447	869
209	505	955	541	1039
212	567	1074	541	1083
215	484	1007	530	1033
218	508	987	547	1067
221	555	1122	568	1088
224	523	1015	581	1133
227	368	996	518	1090
230	439	839	556	1105
233	523	1054	615	1072
236	482	1030	467	972
239	437	914	456	916
242	311	709	409	964
245	180	371	407	849